Glomular function and tubular reabsorption

- Kidneys are concerned with body fluids, total amount of fluids is 42 litres
- Body fluids are divided into 2 parts:
  - Intracellular body fluids: which represents 28 L of total body fluids.
  - Extracellular body fluids: which represents 14 L of total body fluids, it include :
    - Plasma: which represents 3 L.
    - Interstitial fluids and other fluids: which represents 11 L.
- Kidneys has many functions:

1. Excretion of metabolic waste products (urea-creatinine-uric acid)
   - Urea concentration is 15-40 mg/dl
   - Creatinine concentration is 0,5-1,5 mg/dl
   - Uric acid concentration is 2-7 mg/dl

2. Regulation of osmolarity of body fluid, normal osmolarity = 300 osmole/L
3. Regulation of acid-base balance
4. Regulation of arterial pressure (long term regulation)
5. Secretion of hormones, example : erythropoietin and calcitriol.
6. Glucose synthesis:
7. Kidneys has the ability to synthesize glucose from amino acids and other substances during prolong fasting, this process is called gluconeogensis

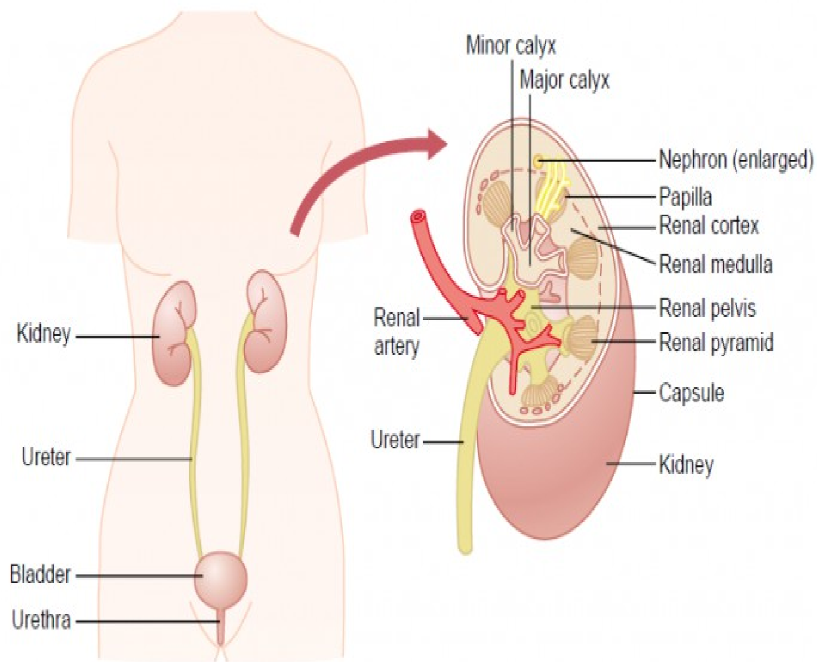

Figure 26–2

General organization of the kidneys and the urinary system.

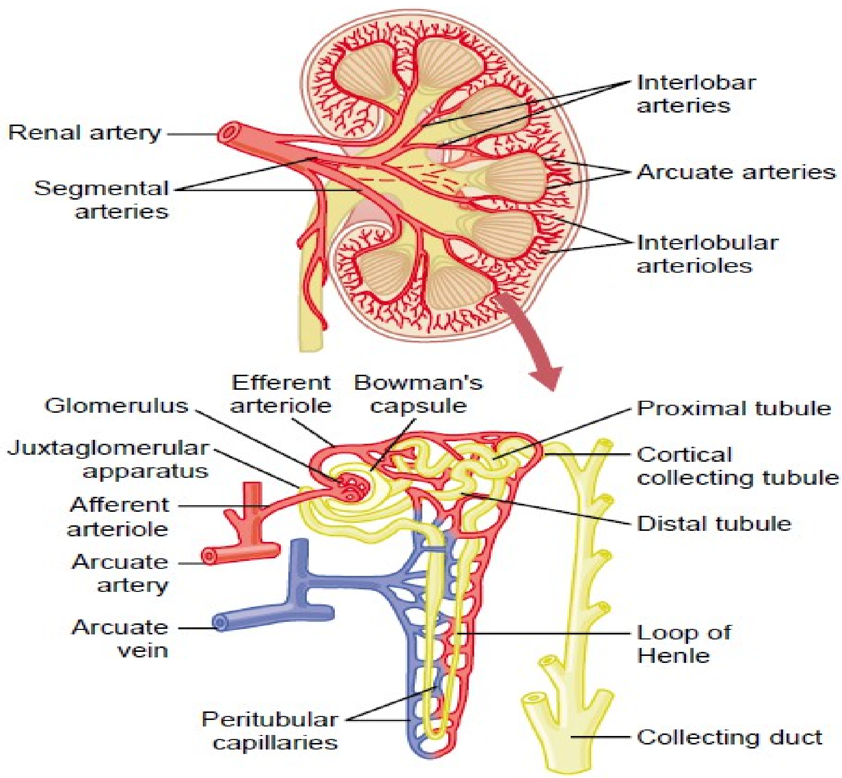

Figure 26–3

Section of the human kidney showing the major vessels that supply the blood flow to the kidney and schematic of the micro-circulation of each nephron.

- The fundamental and functional unit of the kidney is nephron which is composed of glomerulus and long renal tubules, which includes :
  - Proximal tubules
  - Loops of henle
  - Collecting tubules
  - Collecting ducts

❖ In every kidney there is one million nephron

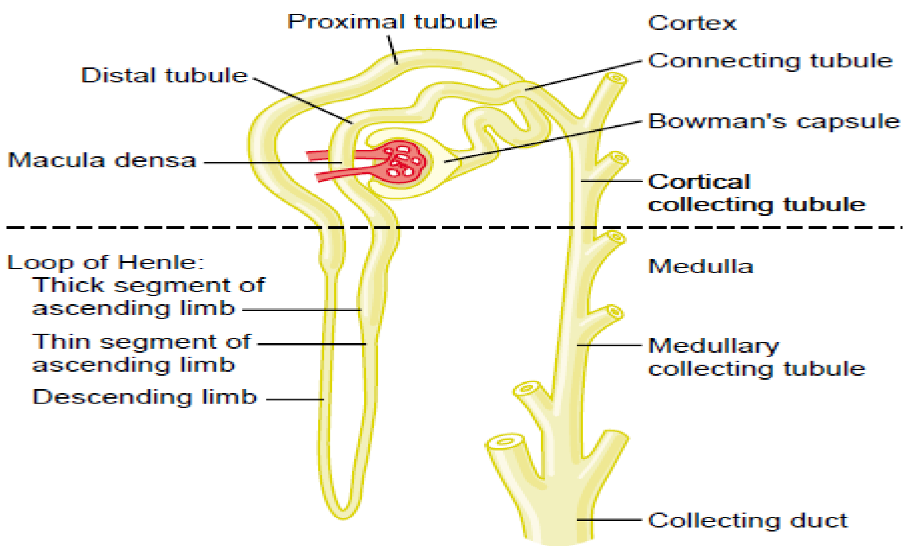

Figure 26–4

Basic tubular segments of the nephron. The relative lengths of the different tubular segments are not drawn to scale.

❖ Glomerular capillaries are responsible for filteration of large amount of fluid from blood to renal tubules, these capillaries are impermeable to cells and relatively impermeable to proteins, so glomerular filtrate doesn't contain cellular components and it is protein free.

Concentration of other ions and molecules in this filtrate is similar to plasma except Ca and fatty acids.
This happens because on half (1/2) of plasma Ca and most of fatty acids of plasma are bond to proteins so they cannot be filtrated through glomerular capillaries.

Glomerular Filtration Rate (G.F.R) is equal to filtrate coefficient (Kf) multiplied by net filtration pressure.

❖ Forces that cause filtration:
  - Glomerular hydrostatic pressure (60 mmHg)

- ❖ Forces that oppose filtration:
  - -Glomerular colloid osmotic pressure (32 mmHg)
  - -Bowman's capsule pressure (18 mmHg)

- So forces that oppose filtration= 50 mmHg ((32 + 18))

- Net filtration pressure, thus = pressure that cause filtration – pressure that oppose filtration
- Net filtration pressure= 60 – 50= 10 mmHg

G.F.R= Kf x net filtrate pressure
=12,5 x 10
= 125 ml/min for both kidneys

G.F.R= 180 L /day

- Glomerular filtration rate = 180 L /day and plasma volume is equal to 3 L meaning that plasma is filtrated 60 times that allows rapid removal of waste products and control of water and electrolyte of body fluids.

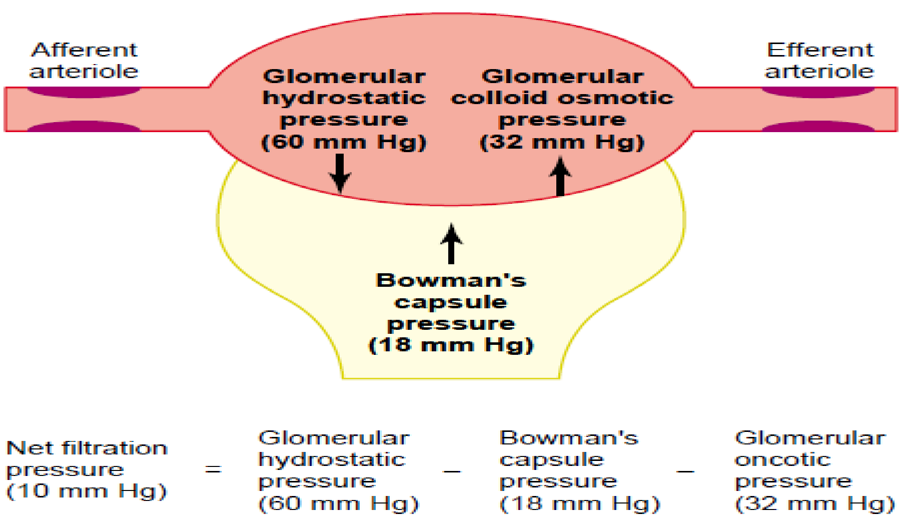

Figure 26–12

Summary of forces causing filtration by the glomerular capillaries. The values shown are estimates for healthy humans.

- ❖ **<u>Kidney stones:</u>**

If there are stones in kidney, obstruction in urine excretion happens.

Stones in ureter are highly painful because ureter is rich with pain receptor, so severe pain and uretric renal reflex occur.

Uretric renal reflex causes constriction of renal arterioles to decrease glomerular filtration to prevent the collection of fluid in order to prevent occurrence of hydronephrosis and damage of kidney

- ❖ **<u>Tubular Reabsorption:</u>**

In long renal tubules reabsorption and secretion occurs
so urine= glomerular filtration – reabsorption + secretion

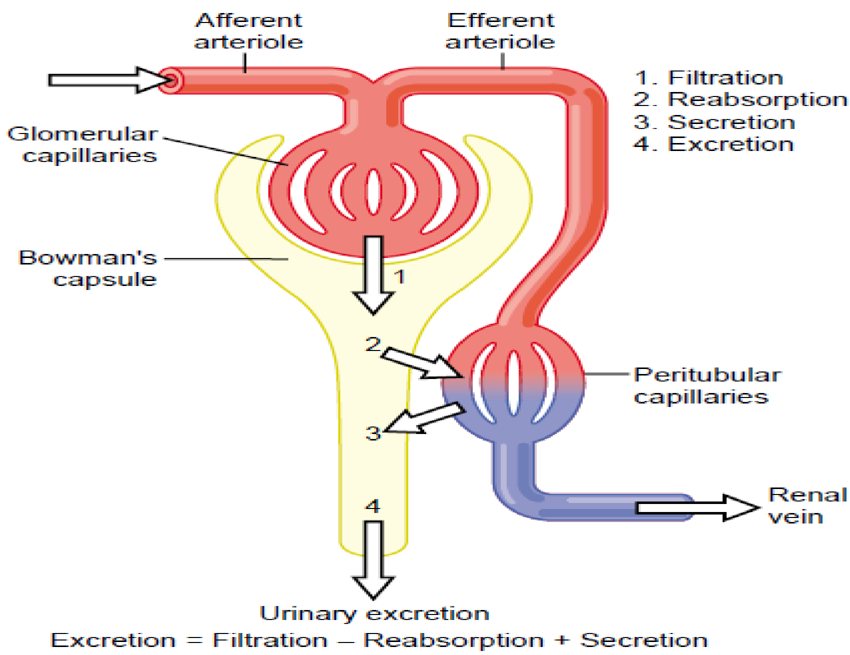

Figure 26–8

Basic kidney processes that determine the composition of the urine. Urinary excretion rate of a substance is equal to the rate at which the substance is filtered minus its reabsorption rate plus the rate at which it is secreted from the peritubular capillary blood into the tubules.

- ❖ Reabsorptive process is highly selective:
  - ➢ Amino acids and glucose are almost completely reabsorbal.
  - ➢ Ions such as Na^+, Cl^- and bicarbonates are also highly reabsorbal.
  - ➢ Waste products are poorly reabsorbed and are excreted in large amounts.

❖ ***Reabsorption of Na^+:***

There is (Na-K) pump allows 3 of Na^+ to be pumped out and 2 of K^+ in. This pump transport Na^+ from interior of the cell across the basement membrane creating a low intracellular Na^+ concentration and a negative electrical potential that cause Na^+ to diffuse to diffuse from the tubular lumen into the cell through the brush border and from the cell interstitial space by basement membrane and then to capillaries.

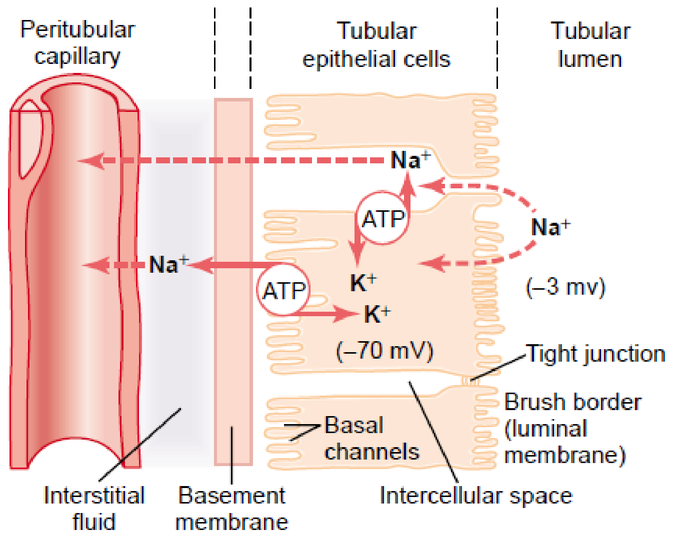

Figure 27–2

Basic mechanism for active transport of sodium through the tubular epithelial cell. The sodium-potassium pump transports sodium from the interior of the cell across the basolateral membrane, creating a low intracellular sodium concentration and a negative intracellular electrical potential. The low intracellular sodium concentration and the negative electrical potential cause sodium ions to diffuse from the tubular lumen into the cell through the brush border.

❖ **Absorption of glucose and amino acids:**

Na-K pumps create electrochemical gradient that causes Na^+ ions to diffuse by facilitated diffusion into tubular cells carrying with it glucose and amino acids, this is called co-transport.

Also this pump provides the energy to transport H^+ ions from inside the cell into tubular lumen.

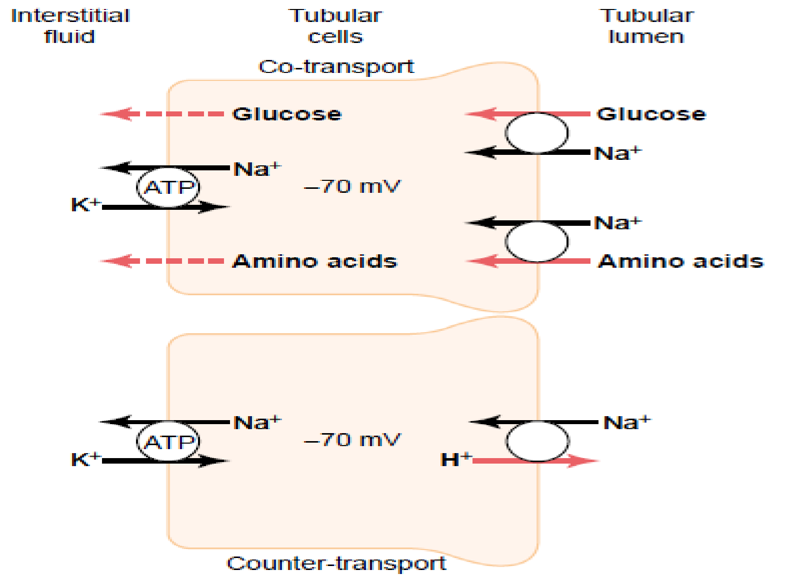

Figure 27–3

Mechanisms of secondary active transport. The upper cell shows the *co-transport* of glucose and amino acids along with sodium ions through the apical side of the tubular epithelial cells, followed by facilitated diffusion through the basolateral membranes. The lower cell shows the *counter-transport* of hydrogen ions from the interior of the cell across the apical membrane and into the tubular lumen; movement of sodium ions into the cell, down an electrochemical gradient established by the sodium-potassium pump on the basolateral membrane, provides the energy for transport of the hydrogen ions from inside the cell into the tubular lumen.

- **Reabsorption of protein:**

Pinocytosis mechanism is active process by which renal tubules can reabsorb proteins.

Proteins are large molecules so it needs this mechanism (pinocytosis).
It begins with the binding of proteins to receptors found on cellular membrane after that this part of cell membrane invaginate to the inside of the cell and separation from cell membrane occurs forming a vesicle with protein inside. Digestion of protein occur inside the vesicle formed and free amino acids then can be absorbed.

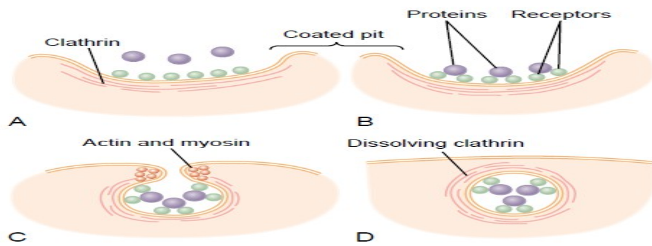

Figure 2–11

Mechanism of pinocytosis.

- **<u>Reabsorption of water by osmosis:</u>**

Solute passes from lumen tubules into interstitial space so increasing concentrations of solutes which leads to water diffusion into interstitial space then to capillaries.

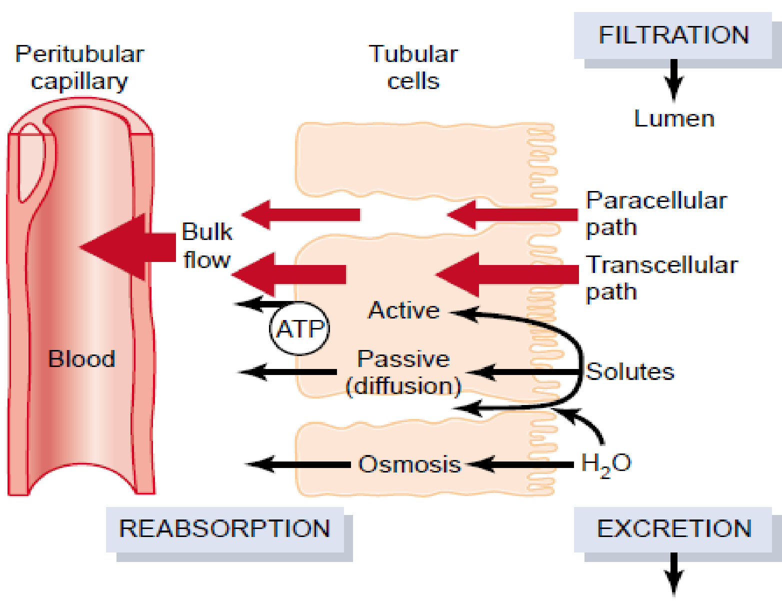

Figure 27–1

Reabsorption of filtered water and solutes from the tubular lumen across the tubular epithelial cells, through the renal interstitium, and back into the blood. Solutes are transported through the cells (transcellular route) by passive diffusion or active transport, or between the cells (paracellular route) by diffusion. Water is transported through the cells and between the tubular cells by osmosis. Transport of water and solutes from the interstitial fluid into the peritubular capillaries occurs by ultrafiltration (bulk flow).

Permeability of water by renal tubules differs, we find that proximal tubules is hughly permeable to water while in distal portion of renal tubules (distal tubules, collecting ducts and collecting tubules) depend on ADH

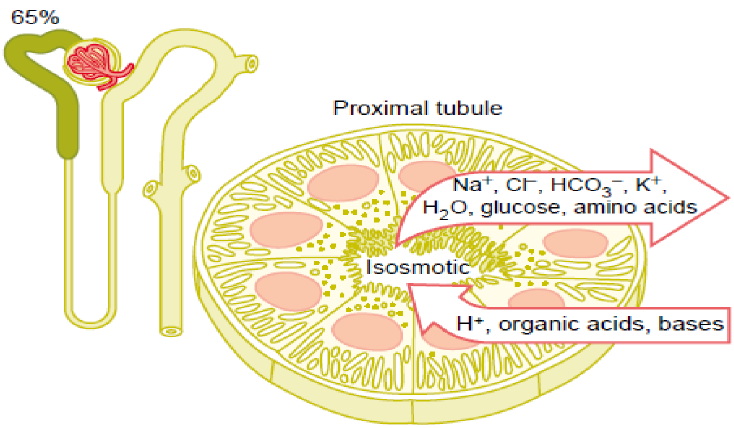

Figure 27–6

Cellular ultrastructure and primary transport characteristics of the proximal tubule. The proximal tubules reabsorb about 65 per cent of the filtered sodium, chloride, bicarbonate, and potassium and essentially all the filtered glucose and amino acids. The proximal tubules also secrete organic acids, bases, and hydrogen ions into the tubular lumen.

- Peritubular capillary reabsorption rate:
  - ✓ There are4 forces concerning reabsorbtion:
    1. Forces that facilitate reabsorption
       - P_{if} (interstitial fluid hydrostatic pressure) = 6mmHg
       - π_c (peritubular capillary colloid osmotic pressure) = 32 mmHg
    2. Forces that oppose reabsorption:
       - P_c (peritubular capillary hydrostatic pressure) = 13 mmHg
       - π_{if} (interstitial fluid colloid osmotic pressure) = 15 mmHg
- ✓ Peritubular capillary reabsorption rate= K_f x net reabsorption pressure

  = 12.4 x 10 = 124 ml/min

  = **178.5** L/day

✓ Filtration rate – reabsorption rate = 1.5 L/day

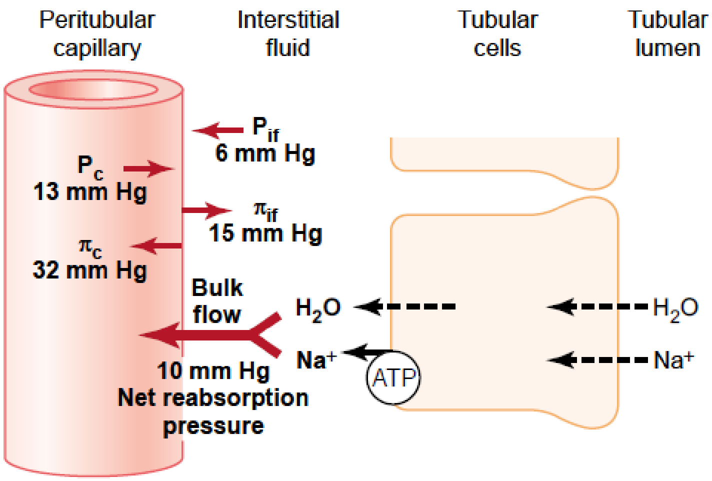

Figure 27–15

Summary of the hydrostatic and colloid osmotic forces that determine fluid reabsorption by the peritubular capillaries. The numerical values shown are estimates of the normal values for humans. The net reabsorptive pressure is normally about 10 mm Hg, causing fluid and solutes to be reabsorbed into the peritubular capillaries as they are transported across the renal tubular cells. ATP, adenosine triphosphate; P_c, peritubular capillary hydrostatic pressure; P_{if}, interstitial fluid hydrostatic pressure; π_c, peritubular capillary colloid osmotic pressure; π_{if}, interstitial fluid colloid osmotic pressure.

❖ <u>Micturation (urination)</u>

When the amount of urine reaches 300-400 in urinary bladder, receptors are stretched so signals are sent to the brain by ascending vesico centry tract in order to have the sensation of urination.

Also signals pass to spinal cord to stimulate parasympathetic motor nerve which causes contraction of smooth muscles of urinary bladder and relaxation of internal urinary sphincter (involuntary one).

Signals are also sent to inhibit sympathetic neuron. Normally sympathetic neuron causes relaxation o muscles of bladder and contraction of **Internal** sphincter. Also inhibition of pudendal nerve occurs by these signals. Normal pudendal nerve causes contraction of external urinary sphincter (voluntary one) So both sphincters are open, so urination occur.

Urination is autonomic spinal cord reflex but it cn be inhibited or activated by brain.

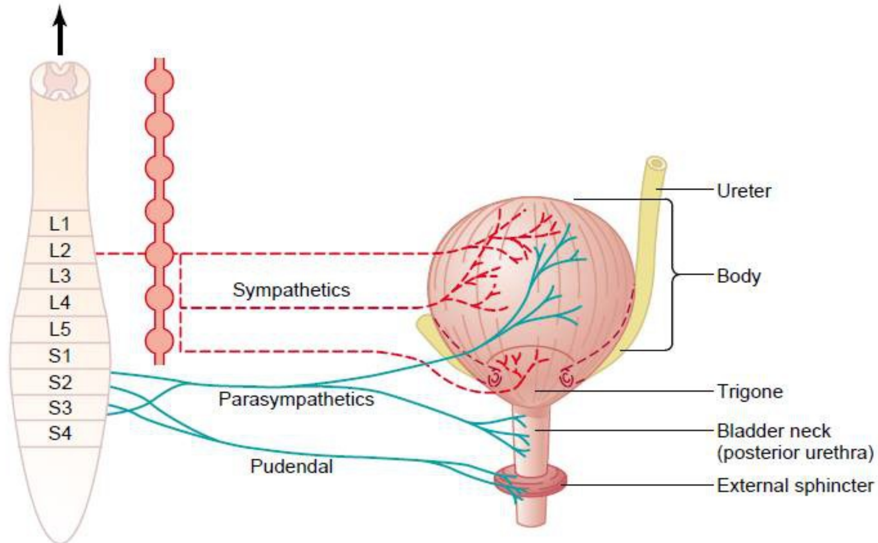

Figure 26–6

Urinary bladder and its innervation.

هذا عمل طلابي في حالة وجود خطأ او سهو يرجى التنبية .